TEXAS AGRICULTURAL EXPERIMENT STATIONS.

BULLETIN NO. 100.

Chemical Section, Dec., 1907.

The Chemical Composition of Some Texas Soils

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POSTOFFICE
COLLEGE STATION, BRAZOS COUNTY, TEXAS.

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THE CHEMICAL COMPOSITION OF SOME TEXAS SOILS.

BY G. S. FRAPS.

This bulletin is a popular account of a study of a nnmber of Texas soils representing large areas. The samples of soils were collected by agents of the Bureau of Soils of the United States Department of Agriculture; the areas have been mapped by them, and the maps, together with a description of the area and the physical composition and properties of the soils, may be secured by anyone interested, on application to the Secretary of Agriculture, Washington, D. C. The following is a list of the publications referred to:

"Soil Survey of Houston County."

"Soil Survey of Anderson County, Texas."

"Soil Survey of the Paris Area, Texas" (Lamar County)

"Soil Survey of the Austin Area, Texas" (Travis County)

"Soil Survey of the San Antonio Area, Texas, (Bexar county)

"Soil Survey of the San Marcos Area, Texas" ((Hays County)

The types of soil represented are not only found in the areas mentioned, but are widely distributed through the State. Since we have found that in general similar types of soil have similar chemical characteristics, the analyses are of more than local interest.

OBJECT OF CHEMICAL ANALYSIS.

The soil may be subjected to chemical analysis in several different ways, and for different objects, the most important of which are as follows:

*First to determine the amount of plant food in the soil which may become useful to plants, and the quantities of other ingredients which affect the plant food favorably or unfavorably. We learn thereby the wearing properties of the soil, and its capabilities under suitable treatment. We also secure valuable indications as to the needs of the soil under definite systems of farming.

Second, to determine the immediate needs of the soil for the plant food; that is, to ascertain what fertilizer constituents should give the greatest returns on a given crop. Chemical analyses with this end in view are, as yet, not entirely satisfactory, but we have hope that a satisfactory method for phosphoric acid and potash will be worked out in the near future.

Pot experiments, in which plants are grown upon portions of the soil in pots, fertilized with different fertilizing ingredients, also show the needs of the soil for plant food. This is the method we used in our work on the soils described in this bulletin.

Third, to ascertain whether or not the soil is acid. A condition of acidity is injurious to most cultivated plants, and can be corrected by applications of lime, or ground limestone.

Fourth, to ascertain if the soil contains alkali in sufficient quantity to be injurious. The alkali in soils consists usually of chloride of soda

* A full account of this work is published as buletin No. 99.

(common salt) and sulphate of soda (Glauber's salt), and is termed "white alkali". Black alkali is due to the presence of carbonate of soda, which dissolves the organic matter in the soil and causes a black color. The alkali in one sample of soil we examined was chloride of calcium. Alkali soils are found in some parts of Texas, but these were not studied in connection with the soils here reported on.

CAUSES OF SOIL FERTILITY.

The size of the crop produced in a given year upon a given soil, depends upon a number of conditions, such as the season, the seed and the treatment given. The fertility, or productiveness, of a soil depends largely upon the treatment it receives, as well as on its chemical composition and properties. The same soil farmed by different persons may produce quite differently; it may also be "built up" by the one, so that its fertility increases, or it may be "run down" by the other until it cannot be cultivated with profit These changes, of course, involve a change in the chemical composition and properties of the soil.

The kind of crop adapted to different soils depends largely upon the physical nature of the soil. Light sandy soils are better suited to early truck: heavy clays to grass and grain. The physical character and the crops adapted to the different types of soil that we studied, are described in publications of the Bureau of Soils to which we have referred.

We wish to emphasize the fact that the productiveness of a soil depends upon other conditions besides its chemical composition and properties. For this reason we cannot analyze a soil and tell how much cotton or corn or potatoes it ought to produce. The treatment of the soil, the season, and other conditions have a great influence.

The plant food in the soil exists in two forms; **active** and **inactive**. We mean by active plant food, that which is in condition to be taken up by the plants. Inactive plant food serves as a reserve store, and is gradually converted into active forms. Only a small portion of the plant food in the soil is at any time in active forms. The rate at which the change from inactive to active plant food takes place, determines to a large extent the fertility of soil. It depends upon the composition and properties of the soil, and the treatment to which it is subjected.

The important chemical constituents of a soil are first, the plant foods which may not be furnished in sufficient quantity, namely, phosphoric acid, nitrogen, and potash; second, the lime; third, the organic matter.

Phosphoric Acid is essential to the growth of the plant. It is deficient in many Texas soils. It occurs in bones, containing 20 to 25 per cent phosphoric acid, in phosphate rock, containing 30 to 35 per cent. and in other forms less abundant. Phosphate rock is usually treated with sulphuric acid, which converts the phosphoric acid into forms which can be easily taken up by plants. The product is known as acid phosphate.

Nitrogen is present in the soil in combination, and free in the air. In its active forms it is easily washed from the soil, considerable quantities being lost in this way. Nitrogen, like other plant food, is removed in the crop. Ordinary crops feed upon the active nitrogen of the soil, but cowpeas, clover, alfalfa, peanuts, vetch, and other leguminous plants have the power of taking nitrogen from the air. Advantage should be taken of this fact to maintain the fertility of the soil in nitrogen. Nitrogen is the most expensive plant food, costing about three times as much as potash or phosphoric acid in fertilizers. The important sources are cottonseed meal, containing about 7 per cent nitrogen; nitrate of soda, 15 per cent; tankage, from slaughterhouses, varys in composition; dried blood, 11 per cent, and bat guano variable, often about 10 per cent.

Potash is needed less often by our soils than phosphoric acid or nitrogen. It is removed in considerable amounts by most crops, though the loss is decreased if the straw, stubble, leaves, etc., are returned to the soil. Potash comes chiefly from Germany, where it is mined from the earth. The principal materials are kainit, containing 12 per cent potash, and muriate and sulphate of potash, about 50 per cent.

Lime is present in the soil in sufficient quantity for plant food, but not always for other purposes. It aids in maintaining a supply of active phosphoric acid, nitrogen, and potash. keeps the soil from becoming acid, and has a favorable effect upon its physical character. Hence a deficiency of lime should be corrected by applications of quicklime, slaked lime, or ground limestone. Lime is lost in considerable quantity in the water which passes through soil.

Organic Matter is the residues from plants and animals, and contains the reserve store of nitrogen in the soil. It is continually being lost by oxidation. Organic matter aids the soil in holding water, has a favorable effect upon its physical conditions, and by itself, and through the products of its oxidation (carbon dioxide), aids in rendering inactive plant food active. A soil rich in organic matter is usually fertile. One step in building up a run down soil is to increase the organic matter in it.

THE SERIES OF SOILS STUDIED.

Soils differing in the size of particles of which they are composed, but alike in origin, nature, and other respects, are grouped by the Bureau of Soils into **series.** The series we have studied are Norfolk soils, Orangeburg soils, Lufkin Susquehanna soils and Houston soils. They have the following characteristics:

Norfolk soils are light colored, upland sandy soils with a yellow sandy subsoil, usually with good drainage. The most important truck soils of the coastal plains are in this group. These soils are abundant in East Texas. Norfolk soils from widely represented areas are very similar in chemical composition. They contain high percentages of insoluble material, and low percentages of phosphoric acid and nitrogen. They are low in organic matter and potash, but often contain sufficient of the latter. These soils respond well to phosphatic and nitrogenous fertilizers, and organic matter is very beneficial.

Orangeburg soils are gray to brown upland soils with a red clay subsoil. The red color of the subsoil distinguishes the Orangeburg from the Norfolk soils. The red soils are more productive and stronger than corresponding Norfolk soils. The Orangeburg soils are better supplied with plant food than the Norfolk soils. Their content of phosphoric acid and nitrogen is low, however, and they respond to fertilizers carrying these plant foods. They are usually low in organic matter.

Lufkin soils are gray soils with heavy, very impervious, plastic gray and mottled subsoils, having a lower agricultural value than the Norfolk or

Orangeburg soil. The Lufkin soils are low in phosphoric acid, nitrogen, and organic matter, and variable in lime.

Susquehanna soils are gray to brown surface soils with heavy plastic mottled subsoils. They are of low agricultural value. They are slightly better supplied with plant food than the corresponding Lufkin soils.

Houston soils are black calcareous soils, very productive and durable, being among the best soils in the state. Some of them have been cultivated 40 to 50 years without fertilizer and are still productive. These soils are generally well supplied with nitrogen and lime. They are variable in phosphoric acid, sometimes very low but generally well supplied. They contain a good supply if organic matter.

. **Yazoo soils** are bottom soils, generally fertile.

THE AREAS STUDIED.

. **Houston county.** The nine soils examined belong to the Norfolk, Orangeburg, Lufkin, and Susquehanna series. All samples were low in phosphoric acid, nitrogen, and organic matter. The two Orangeburg soils are better supplied with phosporic acid than the others. All the samples except the Susquehanna clay appear to contain sufficient potash. The Lufkin and Susquehanna soils are low in lime.

All the soils tested by pot experiments respond to phosphoric acid--the Norfolk fine sand, Norfolk fine sandy loam, Orangeburg fine sandy loam, Susquehanna fine sandy loam and Lufkin fine sand. Only the Norfolk fine sandy loam responds to potash.

Anderson county. The six soils examined belong to the Norfolk, Orangeburg and Yazoo series. All were low in phosphoric acid, and all except the Yazoo clay, in nitrogen. The Norfolk sand and Orangeburg clay are low in potash. All are low in organic matter and lime except the Yazoo clay. The Yazoo clay is a strong soil.

With the pot experiments, all the samples tested respond to phosphoric acid, and the Norfolk sand and Orangeburg clay to potash. The other soils tested are, Norfolk fine sand, Norfolk fine sandy loam, Orangeburg fine sandy loam and Yazoo clay.

Lamar county. Seven of the samples examined belong to the Orangeburg, Houston and Lufkin series. The other two are Sharkey clay and Sanders loam, both bottom land subject to over-flow, and the former very productive.

Phosphoric acid is low in the samples of Orangeburg fine sandy loam, Orangeburg clay, Houston clay, Lufkin clay, and Sanders loam. The other soils, the Orangeburg sandy loam, Orangeburg silty loam,Houston black clay, and Sharkey clay, contain fair to large quantities. Nitrogen is low in the Orangeburg fine sandy loam, Orangeburg clay, and Lufkin clay. The two soils last named are acid. Only the Lufkin clay and Sanders loam were tested by pot experiments. They both responded well to phosphoric acid and slightly to potash.

Travis county. Only four samples were examined, Houston black clay, Yazoo sandy loam, Lufkin fine sandy loam, and Travis gravelly loam.The latter is a coarse sandy loam full of gravel and little suited to cultivation.

Phosphoric acid is low in the Travis gravelly loam and in Lufkin fine sandy loam. Nitrogen is low in the Yazoo fine sandy loam and in Lufkin fine sandy loam. Potash and lime appear to be sufficient in the four samples, in fact, lime is very abundant in some of them. In the pot experiments the Yazoo sandy loam and Houston black clay responded to phosphoric acid, and neither to potash.

Bexar county. Nine samples were examined, all belonging to the Norfolk, Houston, and Orangeburg series, except the following: Portsmouth sandy loam a bluish gray to dark sandy loam, termed "black sand" and little cultivated; San Antonio clay loam, a very productive brownish or chocolate loam; Austin fine sandy loam, a productive yellow to reddish gray sandy loam known as "Shelly land." Some of these soils are well supplied with plant food.

Phosphoric acid is low in the Norfolk sand, Norfolk silty loam, Orangeburg fine sand and Portsmouth fine sandy loam. Nitrogen is low in the Norfolk sand, and in the Orangeburg fine sandy loam. The other soils contain a fair amount. Potash is low in the Norfolk sand and in the Austin fine sandy loam. Nitrogen is low in the Norfolk sand and in the Norfolk silty loam. The Houston soils, the Portsmouth sandy loam, and San Antonio clay contain considerable quantity of lime. According to the pot experiments the soils tested responded to phosphoric acid fertilizers, and the San Antonio clay loam appears to be deficient in potash. The soils tested were the Norfolk sand, the Susquehanna loam, Houston black clay, Orangeburg fine sand, and San Antonio clay loam.

Hays county. The Houston loam, Houston black clay, and Houston clay have already been mentioned. The Crawford soils are residual limestone soils of the prairie regions, characterized by dark brown to reddish brown surface soil and reddish brown red to red subsoil.Crawford stony clay is a dark loam so full of stones as to be unfit for agricultural purposes, although very productive when the stones are removed. Crawford silty clay is a brown to reddish brown clay, being the principal truck soil of the area. Blanco loam is a heavy gray loam or silty loam occurring only in limited areas. Susquehanna fine sandy loam is a gray to light brown sandy loam adapted to a variety of crops, especially watermelons, sweet potatoes, and peanuts. Wabash clay is a heavy black clay subject to overflow, and very productive.

Phosphoric acid is low in the Houston loam and in the Susquehanna fine sandy loam, but other soils contain an abundance. A fair quantity of nitrogen is present in all the soils. Potash is low in Houston clay and in the Blanco loam. These soils as a rule contain large quantities of lime, the exceptions being Houston loam and Susquehanna fine sandy loam.

All the soils tested by the pot experiments responded to application of phosphoric acid, the response being particularly great with the Houston loam and the Susquehanna fine sandy loam. The Houston clay and Susquehanna fine sandy loam respond to fertilization with potash. The soils tested are the Houston loam, Houston black clay, Cr wford stony clay, Susquehanna fine sandy loam, and Wabash clay.

RESULTS OF THE WORK.

In the preceding pages, we have indicated the needs for plant food, organic matter and lime of the various types of soil studied. Since there is some variation in the composition and fertility if different parts of the same type due to natural causes and the treatment which it has received, each farmer must adapt our suggestions to his individual needs. Our work shows that, as a general rule, the soils of Texas need phosphoric acid first, nitrogen next, and potash last and least of all.

It remains for us to make some suggestions as to maintaining the fertility of our soils.

When a crop is removed it carries with it a certain amount of plant food, and unless this fertility is restored the soil gradually loses its fertility. Sooner or later the crop will be decreased. The active plant food decreases more rapidly than the inactive; and the productiveness of a soil, owing to faulty methods of farming, may decrease very rapidly even though a large quantity of plant food is present.

The organic matter in the soil also decreases under clean cultivation unless green crops are ploughed under or quantities of manure are applied. Since organic matter aids in the conversion of inactive to active plant food, the rapidity of this change decreases, as the amount of organic matter decreases. Soils are continually losing lime in the crop and in drainage water. Lime aids in the conversion of inactive plant food into active, affects favorably the physical character of the soil, prevents the soil from becoming acid, and has other favorable effects. A soil originally containing a small quantity of lime may become deficient in this element and receive a decided benefit from applications of lime.

The general principles in maintaining the fertility of the soil are as follows:

First, Maintain or increase the quantity of organic matter in the soil by the use of barn-yard manure or by plowing under cowpeas or other green crops. Our Norfolk and Orangeburg soils are particularly low in organic matter, and respond well to this treatment. A great many Texas soils are low in organic matter, as we have pointed out.

Second, Maintain a sufficient supply of active lime. Most of the soils of the western part of the state contain an abundance of lime. The soils of east Texas may need liming in the near future, in fact, there are some which would respond to an application of lime at present.

Third, Prevent the loss of plant food as far as possible. In feeding, save the manure carefully and then plough it under. Leaves, straw, etc., should not be burned unless it is absolutely necessary, since burning involves a loss of all the nitrogen present. If burned, however, the ashes should be saved carefully and applied to the soil.

Fourth, Deficiency in active phosphoric acid or potash should be overcome by the use of commercial fertilizers. The soils of Texas appear as a general rule to respond to the application of phosphoric acid, though there are some notable exceptions to this rule. Potash is not as generally deficient. We have indicated in this bulletin the soils which should respond to application of fertilizers.

Fifth. Nitrogen should be secured from the air to as large extent as possible, and nitrogenous fertilizer should be used only to supplement supplies so secured. Ordinary crops can secure nitrogen only from the soil, but cowpeas, vetch, peanuts, alfalfa and similar crops have the power of securing nitrogen from the air and it should be the object of every farmer to utilize atmospheric nitrogen in preference to the soil nitrogen to as great extent as possible. Cowpeas can be planted between the rows of corn and ploughed under or fed off to as great an extent as practicable. Alfalfa, peanuts, etc., should be used in preference to cereal grasses for hay, feeding, etc.